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Medical Policy

Subject:	Surface Electromyography and Electrodermal Activity Sensor Devices for Seizure Monitoring		
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Description/Scope

This document addresses devices that use surface electromyography (sEMG) and electrodermal activity sensor devices to monitor seizures. These devices are proposed as an adjunct in recording and storing data for characterization of seizure events.

Note: This document addresses sEMG devices only. sEMG in combination with video electroencephalographic monitoring (vEEG) is not addressed in this document. For information regarding sEMG in combination with vEEG, please see:

- CG-MED-46 Electroencephalography and Video Electroencephalographic Monitoring

Note: Please refer to the following related documents for additional information:

- MED.-00125 Biofeedback and Neurofeedback

Note: Some benefit plans may exclude coverage of consumer wearable or personal mobile devices (such as a smart phone, smart watch, or other personal tracking devices), including any software or applications.

Position Statement

Investigational and Not Medically Necessary:

The use of surface electromyography (sEMG) or electrodermal activity sensor devices for seizure monitoring is considered **investigational and not medically necessary**.

Rationale

There have been a limited number of studies published in the peer-reviewed literature addressing the use of sEMG or electrodermal activity sensor devices for seizure monitoring. Currently, major ~~authoritative~~ professional organizations have not published recommendations on the use of sEMG or electrodermal activity sensor for this indication.

Surface Electromyography

In 2015, Beniczky and colleagues released the results of a prospective study that evaluated the reliability of an automated algorithm based on sEMG to distinguish generalized tonic-clonic seizures (GTCS) from psychogenic nonepileptic seizures (PNES). Individuals (n=24) were admitted to the epilepsy monitoring unit and had simultaneous sEMG recording and vEEG monitoring. Trained experts analyzed the vEEG recordings and were blinded to the results of the algorithm. There were 25 GTCSs identified in 11 individuals and 19 PNESs identified in 13 individuals. As validated by vEEG analysis, the algorithm positively identified 24 of the 25 GTCSs and 18 of the 19 PNESs. There was one false negative event and one false positive event. The algorithm sensitivity was 96% and specificity was 94.7% with an overall diagnostic accuracy of 95.4% and positive predictive value of 96%. While encouraging, these results would need to be confirmed in a larger test sample.

A prospective, single center, phase II study was published in 2015 by Szabó and colleagues. The aim of the study was to validate the sensitivity, specificity, and latency of a seizure-detection algorithm for the analysis of sEMG signals using inpatient vEEG monitoring as the comparator. Between November 2011 and December 2012, 36 individuals with medically refractory epilepsy and a history of GTCS were admitted to the epilepsy monitoring unit, enrolled in the study, and had concurrent sEMG recording and vEEG monitoring. vEEG recordings were independently reviewed and analyzed by at least two epileptologists. The sEMG signal recordings were analyzed offline using a frequency-based, automated algorithm. The reviewers used the following parameters when analyzing the data (Szabó, 2015):

> If a GTCS was identified, by the algorithm, within 60 seconds of the video-EEG onset, it was considered a true positive. If a GTCS was not identified, and EMG was actively being

recorded during the GTCS, the event was considered a false negative. Any seizure alert in the device log not associated with a seizure documented by video-EEG was a false positive. Finally, the time of onset of motor symptoms associated with GTCS observed by video-EEG analysis was correlated with the time of seizure detection by sEMG

Of the 36 individuals enrolled in the study, 3 individuals were not included in the final data analysis due to sEMG recording issues. Out of 196 epileptic seizures recorded in 23 (70%) individuals, 21 were identified by vEEG recording analysis as GTCS in 11 (33%) individuals. The seizure-detection algorithm detected 20 of 21 GTCS (95% sensitivity, 95% confidence interval [CI], 76-100) with an average of 20 seconds of electroclinical onset of generalized tonic activity. There was one false-positive and one false-negative event. While this validation study showed favorable test performance, it was limited by a very small number of analyzed events.

In 2017, Halford and colleagues published a prospective, multicenter, phase III trial that investigated an sEMG monitoring system for the detection of GTCS. In 11 epilepsy centers, 199 individuals were monitored for GTCS by the sEMG seizure monitoring system between August 2013 and December 2015; however, 50 (25%) individuals did not have proper placement of the sEMG device or had technical issues, such as sEMG data not being archived for reprocessing, but were still included in the trial. There were 29 (15%) individuals who withdrew from the trial early; however, the sEMG data recorded prior to withdrawal was included in the final data analysis. Three vEEG reviewers, who were not study site investigators, evaluated system detections and GTCS identified by clinical care providers. Using a majority rules approach, the data was independently adjudicated by the vEEG reviewers, who were blinded to system detections and sEMG recordings. Results showed that 37 (19%) of the individuals had at least one GTCS with a total of 46 GTCS identified with vEEG. The sEMG device detected 35 of the 46 GTCS (76%; 95% CI, 0.65-1.0) with a mean false alarm rate (FAR) of 2.5 per 24 hours. For data recorded while the device was appropriately positioned over the midline of the biceps muscle, the test system detected 29 of 29 GTCS (100%; 95% CI, 0.88-1.00) with a mean FAR of 1.44 per 24 hours (Halford, 2017). However, FAR for those properly wearing the device varied between 0 and 10 per 24hr. The results of this small validation study are promising, but challenged by a high false alarm rate for many of the users.

Beniczky and colleagues (2018) reported on the results of a prospective, multicenter study that evaluated the accuracy of an sEMG device in the detection of GTCS in 71 individuals at 3 centers between October 2014 and January 2017. Individuals underwent vEEG monitoring as a comparison for the sEMG device and results were reviewed by three clinical neurophysiologists and epileptologists who were blinded to all sEMG device data until the analysis of the vEEG recordings was completed. The data showed that 20 (28%) individuals had at least 1 GTCS with a total of 32 GTCS. The sensitivity of the sEMG device, defined as the percentage of GTCS detected,

was 93.8% (30 out of 32 GTCS) (95% CI, 86%-100%). The specificity of the sEMG device, defined as the FAR, was 0.67 per day. There were a total of 161 seizures other than GTCS that were identified in the vEEG recordings.

Validation studies published to date are limited to studies performed in an inpatient setting. It is unclear if the test performance of sEMG monitoring of GTCS in an ambulatory or home setting would be similar to the results obtained the inpatient settings described above. It is also unclear as to how using sEMG monitoring for GTCS would impact the management and treatment outcome (for example, seizure frequency, status epilepticus, aspiration, injury or death) of individuals with this disorder. Randomized, prospective comparative trials demonstrating the clinical utility of the device are needed.

Electrodermal Activity Sensor Devices

In 2022, Naganur and colleagues conducted a systematic review and meta-analysis of studies reported up to November 2021. This study was to review the performance of noninvasive wearable devices detecting epileptic seizures and psychogenic nonepileptic seizures. The review included 23 studies. The detection of both tonic-clonic seizures and focal seizures were included in 4 studies consisting of 189 individuals (median =35, IQR = 27.25-55). A total of 224 focal and tonic-clonic seizures were recorded during video electroencephalographic monitoring. Of the 244 seizures, 166 were detected by the wearable and noninvasive devices (overall sensitivity of 74.1%). The total number of false alarms detected in the four studies was 259 (median = 46, 95% CI = 37.3 – 73.6). The authors noted that future studies should focus on reducing the false alarm rate.

A systematic review and meta-analysis completed by Ortega and colleagues (2022) aim to estimate the incidence of electrodermal response during seizures. At total of 19 studies were included in the review. Of the 19, six studies were considered for meta-analysis. The polled incidence of electrodermal activity response during seizures was 82 per 100 seizures (95% CI 70-91). The studies included in this review were carried out in controlled conditions and on hospitalized individuals making it difficult to evaluate the applicability of the findings in an ambulatory setting. The authors concluded that further research is needed to better evaluate the factors in an electrodermal activity response and to investigate pre-ictal electrodermal activity changes.

At this point in time, the peer reviewed published evidence addressing electrodermal active sensor device is weak. Additional evidence in the form of well–designed and conducted clinical trials is needed to help elucidate potential health outcome benefits as well as the role of this type of device in the non–investigational setting and how use of these devices will improve management and outcomes of seizure disorders.

Background/Overview

Surface Electromyography

sEMG devices have been proposed as an adjunct in recording and storing data for characterization of seizure events in the home or healthcare facilities during periods of rest. The sEMG device is placed on the belly of the biceps muscle of an individual. An alarm alerts caregivers when the device detects signal patterns associated with unilateral, appendicular, tonic extension that is potentially related to a GTCS. While continuing to record sEMG data for future review, the alarms can be turned off by a physician order (U.S. Food and Drug Administration, 2019).

The U.S. Food and Drug Administration (FDA) cleared the SPEAC® System (Brain Sentinel, Inc., San Antonio, TX), formerly known as the Brain Sentinel® Monitoring and Alerting System (Predicate), through the 510(k) premarket approval process on May 11, 2019 as an adjunct to seizure monitoring in adults in the home or healthcare facilities during periods of rest. The SPEAC System Traditional 510(k) Summary lists several warnings and limitations, including (FDA, 2019):

- The System should not be used as a standalone monitor for monitoring seizures and is not intended to be used during physical activity.
- The System alarms are not for standalone use and should not be used to guide medical therapy decisions
- The System has not been demonstrated to affect any clinical outcome such as status epilepticus, brain damage, or death following a GTC seizure
- The System does not predict sEMG signals that may be associated with GTC seizures
- The device provides an alert following the onset of sEMG activity that may be associated with a GTC seizure
- The System does not predict seizure onset
- The safety and effectiveness of the System has not been established in pediatric populations
- The safety and effectiveness of the SPEAC System has not been established in monitoring sEMG signals that may be associated with seizures other than the GTC seizure.

New features in the SPEAC System compared to the Brain Sentinel Monitoring and Alerting System include an increase in the surface area of the electrode patch and a feature for the physician to turn off alarms while still recording data. Currently, there are no other FDA cleared sEMG devices for seizure monitoring.

Electrodermal Activity Sensor Devices

The U.S. Food and Drug Administration (FDA) cleared the Embrace2 (Empatica Inc., Cambridge, MA) through the 510(k) premarket approval process on December 20, 2018 as an adjunct to seizure monitoring in adults and children age 6 years and older in home or healthcare facilities during periods of rest. The device is worn on the wrist, and senses Electrodermal Activity (EDA) and motion data to detect patterns that may be associated with generalized tonic clonic seizures in ~~patients~~individuals with epilepsy or at high risk of having epilepsy. When a seizure event is detected, Embrace sends a command to a paired wireless device that is programmed to initiate an alert to a designated caregiver. The system records and stores data from Accelerometers, EDA, and temperature for subsequent review by a trained healthcare professional.

Definitions

Electroencephalography (EEG): A test that involves recording of the electrical activity of the brain (brain waves).

Epilepsy: A condition of the brain where an individual is prone to repeated seizures.

Generalized seizure: A seizure that begins with a widespread electrical discharge involving both sides of the brain at once.

Seizure: An excessive surge of electrical activity in the brain, usually lasting from a few seconds up to a few minutes, causing a wide range of symptoms or effects depending on which parts of the brain are involved in the abnormal electrical activity.

Tonic-clonic seizure: A seizure of sudden onset involving generalized stiffening and subsequent rhythmic jerking of the limbs.

Coding

The following codes for treatments and procedures applicable to this document are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement policy. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

When services are Investigational and Not Medically Necessary:
For the following procedure codes; or when the code describes a procedure indicated in the Position Statement section as investigational and not medically necessary.

HCPCS	
E1399	Durable medical equipment, miscellaneous [when specified as a mobile-based software application to monitor seizures using electrodermal activity, e.g., Embrace2]
S3900	Surface electromyography (EMG)
ICD-10 Procedure	
4A0FX3Z	Measurement of musculoskeletal contractility, external approach
ICD-10 Diagnosis	
G40.001-G40.919	Epilepsy and recurrent seizures

References

Peer Reviewed Publications:

1. Beniczky S, Conradsen I, Henning O, et al. Automated real-time detection of tonic-clonic seizures using a wearable EMG device. Neurology. 2018; 90(5):e428-e434.
2. Beniczky S, Conradsen I, Moldovan M, et al. Automated differentiation between epileptic and nonepileptic convulsive seizures. Ann Neurol. 2015; 77(2):348-351.
3. Halford JJ, Sperling MR, Nair DR, et al. Detection of generalized tonic-clonic seizures using surface electromyographic monitoring. Epilepsia. 2017; 58(11):1861-1869.
4. Naganur V, Sivathamboo S, Chen Z, Kusmakar S, ET AL. Automated seizure detection with noninvasive wearable devices: A systematic review and meta-analysis. Epilepsia. 2022 Aug;63(8):1930-1941.
5. Casanovas Ortega M, Bruno E, Richardson MP. Electrodermal activity response during seizures: A systematic review and meta-analysis. Epilepsy Behav. 2022 Sep;134:108864.
6. Szabó CÁ, Morgan LC, Karkar KM, et al. Electromyography-based seizure detector: preliminary results comparing a generalized tonic-clonic seizure detection algorithm to video-EEG recordings. Epilepsia. 2015; 56(9):1432-1437.

Government Agency, Medical Society, and Other Authoritative Publications:

1. U.S. Food and Drug Administration 510(k) Premarket Notification Database. SPEAC® System Traditional 510(k) Summary. No. K182180. Rockville, MD: FDA. May 11, 2019. Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm?ID=K182180. Accessed on ~~September 22~~October 10, ~~2021~~2022.
~~1.~~2. U.S. Food and Drug Administration 510(k) Premarket Notification Database. Embrace Traditional 510(k) Summary. No. K181861. Rockville, MD: FDA. December 20, 2018. Available at: https://www.accessdata.fda.gov/cdrh_docs/pdf18/K181861.pdf. Accessed on October 10, 2022.

Websites for Additional Information

1. Epilepsy Foundation. Available at: https://www.epilepsy.com/. Accessed on October 11, 2022.

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The use of specific product names is illustrative only. It is not intended to be a recommendation of one product over another, and is not intended to represent a complete listing of all products available.

Document History

Status	Date	Action
Revised	11/10/2022	Medical Policy & Technology Assessment Committee (MPTAC) review. ~~Updated~~Revised title and position statement by adding electrodermal activity sensor devices. Updated Scope, Rationale, Background/Overview, References, and Index sections. Updated Coding section; added E1399 NOC code.
Reviewed	11/11/2021	~~Medical Policy & Technology Assessment Committee (~~MPTAC~~)~~ review. Updated References section.
Reviewed	11/05/2020	MPTAC review. Updated References section.
Reviewed	11/07/2019	MPTAC review. Updated Description, Rationale, and References sections.
New	08/22/2019	MPTAC review. Initial document development.

This Medical Policy provides assistance in understanding Healthy Blue's standard Medicaid benefit plan. When evaluating coverage for a specific member benefit, reference to federal and state law, as well as contractual requirements may be necessary, since these may differ from our standard benefit plan. In the event of a conflict with standard plan benefits, federal, state and/or contractual requirements will govern. Before using this policy, please check all federal, state and/or contractual requirements applicable to the specific benefit plan coverage. Healthy Blue reserves the right to modify its Policies and Guidelines as necessary and in accordance with legal and contractual requirements. This Medical Policy is provided for informational purposes. It does not constitute medical advice. Healthy Blue may also use tools and criteria developed by third parties, to assist us in administering health benefits. Healthy Blue's Policies and Guidelines are intended to be used in accordance with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.